Research Note

Bacteriological Profile of Raw, Frozen Chicken Nuggets

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ABSTRACT

The bacteriological profile of raw, frozen chicken nuggets manufactured at a chicken processing facility in Queensland, Australia, was determined. Chicken nuggets are manufactured by grinding poultry, adding premixes to incorporate spices, forming the meat to the desired size and shape, applying a batter and breading, freezing, and packaging. A total of 300 frozen batches were analyzed for aerobic plate count, Escherichia coli, and Salmonella over a period of 4 years. The mean of the aerobic plate count was 5.4 log CFU/g, and counts at the 90th, 95th, and 99th percentiles were 5.7, 5.9, and 6.5 log CFU/g, respectively. The maximum number of bacteria detected was 6.6 log CFU/g. E. coli prevalence was 47%, and of the positive samples, the mean was 1.9 log CFU/g; counts at the 90th, 95th, and 99th percentiles were 2.3, 2.4, and 2.8 log CFU/g, respectively. The maximum number of E. coli was 2.9 log CFU/g. The Salmonella prevalence was 8.7%, and 57.7% of these isolates were typed as Salmonella subspecies II 4,12,11 b:e,n,x (Soñia), a low-virulence serotype well adapted to Australian poultry flocks. There was a significant relationship (P < 0.05) between season and both aerobic plate counts and E. coli counts, and no correlation between E. coli counts and Salmonella prevalence. This study provides valuable data on the bacteriological quality of raw, frozen chicken nuggets.

Annual chicken meat consumption in Australia has increased from 6 kg per person in 1965 to 35 kg per person in 2005 (5). Breaded raw chicken products consist of raw chicken, cereal premixes incorporating spices, and batter and breading systems. The bacteriological quality of such products would be expected to reflect closely the bacteriological quality of raw chicken meat, which is its greatest component. Dishes containing chicken meat are of critical importance to the Australian food industry, as they are the single most common food vehicles implicated in Australian outbreaks of foodborne disease (12). The cost of these outbreaks is difficult to quantify but are considered high (1).

Although it is established that chicken and chicken-containing products are responsible for a high proportion of foodborne illness in Australia, there is a data gap on the bacteriological quality and hence, potential contribution to foodborne illness of raw breaded chicken intended to be cooked. There are no Food Standards Australia New Zealand Food Standards Code bacteriological guidelines for this category of product, and it would not be appropriate to apply ready-to-eat guidelines to a raw product that cannot be expected to be free of bacteria (11). In this survey, we used the aerobic plate count as both an indicator of process control and as a means of observing trends over time. The generic E. coli test was used as an indicator of fecal contamination. Finally, the prevalence of Salmonella—one of the most prevalent pathogens isolated from chicken—was compared with that from other studies, and serotypes isolated in this survey were compared with those from human cases of salmonellosis.

MATERIALS AND METHODS

Sampling. A poultry processing plant in Queensland, Australia, participated in this survey. A batch composite was sampled by drawing 100 g of frozen product across the day’s production. Sampling was matched to year-round production and took place at least weekly but often times twice weekly. Each day’s production was sampled and corresponded to one batch. Each batch was classified as belonging to summer, autumn, winter, or spring, based on the date of production; the Southern Hemisphere experiences summer from December to February. Samples were transported to the laboratory in chilled, hard containers. A total of 300 frozen batches were sampled and analyzed for aerobic plate count (APC), E. coli, and Salmonella from January 2003 to December 2006.

Microbiological analysis. Once received into the laboratory, the 100-g sample was mixed, and a 10-g subsample was homogenized with 90 ml of 0.1% sterile peptone solution (Amyl Media, Melbourne, Australia) and stomached for 1 min for APC and E. coli counts. Appropriate dilutions were plated on APC Petrifilm plates (3M, St. Paul, Minn.). APC Petrifilm plates were incubated at 35°C for 48 h and counted according to manufacturer’s instructions, following AOAC International method 990.12 (2). The limit of detection on APC Petrifilm was <100 CFU/g. For E. coli, appropriate dilutions were plated on dry rehydratable film (coli-form and E. coli Petrifilm, 3M). E. coli Petrifilm plates were incubated at 35°C for 48 h and counts determined according to the manufacturer’s instructions, following AOAC International method 991.14 (3). The limit of detection on Petrifilm was <10 CFU/g. In addition, 25 g of each sample was enriched in 225 ml of

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TABLE 1. Microbiological profile of raw, frozen chicken nuggets, from January 2003 to December 2006

<table>
<thead>
<tr>
<th>Analyte</th>
<th>n</th>
<th>Prevalence, % (n)</th>
<th>Mean</th>
<th>Median</th>
<th>90th percentile</th>
<th>95th percentile</th>
<th>99th percentile</th>
<th>Maximum</th>
</tr>
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<tbody>
<tr>
<td>APC(^a)</td>
<td>300</td>
<td>100 (300)</td>
<td>5.4</td>
<td>4.9</td>
<td>5.7</td>
<td>5.9</td>
<td>6.5</td>
<td>6.6</td>
</tr>
<tr>
<td>E. coli(^b)</td>
<td>300</td>
<td>47 (141)</td>
<td>1.9</td>
<td>1.5</td>
<td>2.3</td>
<td>2.4</td>
<td>2.8</td>
<td>2.9</td>
</tr>
<tr>
<td>Salmonella</td>
<td>300</td>
<td>8.7 (26)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Salmonella subsp. I</td>
<td></td>
<td>3.7 (11)</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Salmonella Typhimurium</td>
<td></td>
<td>2.3 (7)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Other(^c)</td>
<td></td>
<td>1.3 (4)</td>
<td></td>
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<tr>
<td>Salmonella subsp. II (Sofia)</td>
<td></td>
<td>5.0 (15)</td>
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</table>

\(^a\) Limit of detection is 100 CFU/g.
\(^b\) Statistical analysis applies only to positive samples. Limit of detection is 10 CFU/g.
\(^c\) Virchow (2), Infantis (1), and Agona (1) make up the remaining Salmonella subsp. I serotypes.

buffered peptone water for 24 h at 35°C and examined for Salmonella. Enrichment cultures were analyzed using the Salmonella BAX Automated System (DuPont Qualicon, Wilmington, Del.) according to manufacturer’s instructions, following AOAC International method 2003.09 (4). Presumptive-positive samples were confirmed by streaking retained buffered peptone water cultures onto xylose lysine desoxycholate agar (Amyl Media) and bismuth sulfite agar (Difco, Becton Dickinson, Sparks, Md.). Xylose lysine desoxycholate agar and bismuth sulfite agar plates were incubated at 37°C for 24 and 48 h, respectively. Typical colonies were streaked on cystine lactose electrolyte deficient medium (Amyl Media) and incubated at 37°C for 24 h. Salmonella was confirmed biochemically and serologically using Medvet Microbact 24E strips (Medvet Science, Adelaide, Australia) and the Serobact Salmonella latex agglutination kit (Medvet Science). Salmonella isolates were cultured onto plate count agar (Amyl Media) and sent to the Queensland Public Health Laboratory, Brisbane, Australia, for serotyping. Results were reported as detected or not detected in 25 g.

Statistical analysis. The relationship between APC, E. coli, and seasonality was analyzed using analysis of variance (ANOVA) in MINITAB statistical software (release 15.1, Minitab, Inc., State College, Pa.). The relationship between E. coli counts and Salmonella prevalence was analyzed using ANOVA testing of E. coli mean counts in the group scored as Salmonella positive versus the group scored as Salmonella negative. The linkage between APC, E. coli, and season, as well as that between E. coli counts and Salmonella prevalence was regarded significant, when an observed P value was <0.05.

RESULTS AND DISCUSSION

Results are summarized in Table 1. The overall Salmonella prevalence was 8.7%, composed of 3.7% Salmonella enterica subspecies I, and 5% S. enterica subspecies II. All of the Salmonella subspecies II isolates were typed as 4,12,[27]:b:e,n,x (Sofia).

Raw chicken nuggets are composed primarily of raw poultry. Two subjective groupings based on Salmonella prevalence in retail level poultry were suggested by Bohachuk (6). These consisted of the “high” group, isolating Salmonella at the levels of 30 to 60% (Canada, Spain, Belgium, Maryland, Spain, and Portugal), and the “low” group, isolating Salmonella at the levels of 4.2 to 11% (Washington, D.C.; Wales; Italy; and Northern Ireland). The prevalence of Salmonella within the raw chicken nuggets in this survey falls within the low grouping.

The 8.7% Salmonella prevalence in this study is lower in comparison with the results of other microbiological surveys of raw chicken–containing products. A laboratory survey by researchers in Quebec, Canada, who surveyed 106 chicken nugget samples, reported a 30% Salmonella prevalence rate (7). In that study, chicken nuggets from only 11 of the 14 manufacturers were raw products. In contrast to cooked nuggets, raw nuggets have been responsible for numerous foodborne outbreaks compounded by consumer confusion and resultant mishandling of raw, flash-fried products with fully cooked commercially sterile products (7, 11, 14).

Salmonella Sofia was responsible for 59% of Salmonella isolates in this survey. Sofia is a low-virulence serotype extremely well adapted to Australian poultry flocks (9, 10). A previous Australian survey of raw chicken in the Australian Capital Territory presented with an overall prevalence of 41%, and 51 of 100 isolates were Salmonella Sofia (13). It is noted that despite this elevated Salmonella prevalence in raw chicken samples, Salmonella Sofia did not figure in any of the Australian Capital Territory clinical isolates over that same period. On a national scale, Salmonella Sofia represents approximately half of all chicken isolates of Salmonella submitted for typing to the Australian Salmonella Reference Centre (16). Despite this ubiquitous distribution, Salmonella Sofia is almost never associated with human disease either domestically or abroad (16). The benign colonization of Salmonella Sofia in chickens (since the 1980s) is peculiar and fortuitous to Australia. There were 11 non-Sofia Salmonella isolates making up the balance of isolates in this survey, and these were predominantly typed as Salmonella Typhimurium.

The APC and E. coli levels were used by the poultry processing facility both as an indicator of process control and as a means of observing trends over time. There was a significant relationship (P < 0.05) between season and both APC and E. coli count. Aerobic plate counts were lowest in winter, and E. coli counts were highest in summer. An E. coli prevalence of 47%, indicative of poultry carcass input cross-contamination and proliferation, did not corre-
late with the presence or absence of Salmonella, suggesting a possible non-fecal route of Salmonella contamination. Raw nugget quality should be considered not solely as a subgroup of raw poultry quality, but within the context of a product comprising numerous inputs. These inputs include cereal premixes incorporating spices, batter systems, grinding ice, and processing environment. Spices in particular have been implicated with fecal contamination and prolonged survival of Salmonella in foods (13). Nevertheless, one can surmise, based on the isolation of primarily poultry related Salmonella isolates, that non-poultry inputs play no significant role in Salmonella prevalence of breaded, raw poultry products.

This survey highlights the potential health risks of raw, frozen poultry products if not cooked and heated appropriately. The contamination of raw poultry products by Salmonella, although mitigated by the dominance of Salmonella Sofia, provides a challenge that must be managed (15). Management includes use of a hazard analysis critical control point food safety system with elements involving a thermal process to destroy vegetative pathogens and control of cross-contamination from raw meat to cooked product. At least one recent Australian survey of cooked, ready-to-eat retail level poultry products reported a microbiological quality that did not appear to suggest public health concern (8).

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REFERENCES